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# Still too hot: Examination of water temperature and water heater characteristics 24 years after manufacturers adopt voluntary temperature setting

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## Abstract

**Objective—**Although water heater manufacturers adopted a voluntary standard in the 1980's to pre-set thermostats on new water heaters to 120°F, tap water scald burns cause an estimated 1,500 hospital admissions and 100 deaths per year in the United States. This study reports on water temperatures in 976 urban homes and identifies water heater and household characteristics associated with having safe temperatures.

**Methods—**The temperature of the hot water, type and size of water heater, date of manufacture and the setting of the temperature gauge were recorded. Demographic data including number of people living in the home and home ownership were also recorded.

**Results—**Hot water temperature was unsafe in 41% of homes. Homeowners were more likely to have safer hot water temperature (≤ 120°F) than renters (63% vs. 54%; $p<0.01$). For 11% of gas water heaters, the water temperature was ≥ 130°F, although the gauge was set at less than 75% of its maximum setting. In a multivariate logistic regression, electric water heaters were more likely to have safe hot water temperatures than gas water heaters (OR=4.99; $p<0.01$). Water heaters with more gallons per person in the household were more likely to be at or below the recommended 120°F.

**Conclusions—**Our results suggest that hot water temperatures remain dangerously high for a substantial proportion of urban homes despite the adoption of voluntary standards to preset temperature settings by manufacturers. This research highlights the need for improved prevention strategies such as installing thermostatic mixing valves to ensure a safer temperature.

### Keywords

Scald burns; water heaters; Thermostatic mixer valves; passive strategies for injury prevention

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## Introduction

Burns from tap water result in an estimated 1500 hospital admissions and approximately 100 deaths per year.[1,2] The severity of tap water scalds depends on the temperature of the water and the length of time the skin is exposed.[2] Human exposure to hot water at 140°F can lead to a serious burn within 3 seconds, whereas at 120°F a serious burn takes about 10 minutes.[3] Because thinner skin burns more quickly, children and older adults are at increased risk. Young children are disproportionately affected by scald burns, as approximately 21,000 children are treated for scald burns from all causes each year,[4] and scald burns represent an estimated 65% of burn hospitalizations for children ages 4 and under.[4] Hot tap water causes nearly 25% of all scald burns and is associated with more scald burn deaths and hospitalizations in children than any other hot liquid.[5,6,7,8] Data from the National Electronic Injury Surveillance System reveal that during 2001 to 2006 among adults over 65 years there were an estimated 51,700 emergency department visits for scald burns from all causes.[9] Compared to younger adults, the elderly who suffer scald burns from tap water have higher death rates, longer hospitalizations, and more severe health outcomes.[10,11] In addition to age, lower socioeconomic status has also been associated with increased risk for scald burns from all causes.[10,12,13,14]

The economic burden stemming from scald burns is enormous. In the United States, the annual cost for scald burn deaths and injuries from all causes among children 14 years and younger is about $44 million and children younger than 5 years contribute over 90% of this cost.[4] For New York City alone, societal cost estimates for tap water scald injuries to people of all ages from 1996 to 2003 were between $102 and $149 million.[12]

Tap water scalds primarily occur in residential kitchens and bathrooms.[15] Scalds in the bath are especially hazardous for young children because of the large surface area of the body exposed during bathing.[16] Some common mechanisms of scald injury in the bathroom include falling into the bathtub, coming into contact with hot running water, and being placed into excessively hot water accidentally or intentionally.[16]

### Intervening to Reduce Tap Water Scalds

The Consumer Product Safety Commission (CPSC) recommends that water heater manufacturers preset the temperature of water heaters to 120°F. Efforts to regulate tap water temperature at the state level began in Florida in 1980 when the state legislature called for water heater temperatures to be pre-set at 125°F.[17] In response to the Florida effort and similar laws in other states, manufacturers voluntarily adopted the 120°F standard recommended by CPSC in 1988.[7, 15, 17,18] Few studies on the prevalence of hot water temperatures at or below this recommended level have been conducted since this standard was adopted. Gielen et al. observed 63% of families with safe hot water temperature[19] while Shields et al. reported 64% of homes with older adults having safe hot water temperature.[20]

While these data demonstrate that many homes have unsafe water temperatures, the impact of mandating the 120°F setting on new water heaters as a passive injury prevention strategy has been specifically evaluated twice, with mixed results. In 1983 Washington state enacted legislation which required manufacturers to preset the temperature of new water heaters and

landlords to set the temperature of water heaters used in rental properties at 120°F.[15,17] This intervention resulted in significantly reduced household hot water temperatures and injuries resulting from scalds in King County, Washington.[17] In 1996, the New York City Administrative Code was amended to require that all multi-unit dwellings constructed or renovated after 1997 have water heaters set at 120°F.[12] Unlike in Washington, the evaluation did not find an effect of this law on the incidence of tap water scald burns.[12]

Considering the demands on and the design of water heaters, delivering hot water at a consistent temperature is difficult. As a hot water tank is depleted, replenished and reheated, water temperature will not be constant throughout the tank. Water heater thermostats are not designed to provide precise estimates of water temperatures but instead to activate heating elements when water temperature falls below the set temperature. The American National Standards Institute codes allow for water temperatures to vary 10 degrees above and below the thermostat setting.[21] In addition, the gauge controlling the thermostat often follows arbitrary units such as a 1-10 scale as opposed to a temperature scale (like found on an oven). Furthermore, the temperature at the tap may be affected by the length, material and insulation of the pipes carrying the water. For these reasons, the gauge on a water heater may be unreliable as an indicator of the hot water temperature at the tap. However, we could find no studies reporting on the relationship between gauge setting and actual temperature.

The research reviewed above describes the risk of injury associated with tap water scald burns and the efforts of advocates and water heater manufacturers to reduce these risks. Despite these efforts, the fact that thousands continue to suffer tap water scalds suggests that many homes still have unsafe hot water temperatures. To our knowledge, there have been no investigations of how the various types of water heaters and gauge settings may contribute to the problem. As part of a larger study of fire and burn risks in an urban area, we had an opportunity to shed some light on this issue. The aims of this paper are to describe the observed temperature of hot water in a large sample of urban homes; and to identify water heater and household characteristics associated with temperatures at unsafe levels.

## Methods

Water temperatures were tested as part of a home observation in follow-up to a randomized community trial which aimed to improve home safety.[22] The trial included a visit from the Baltimore City Fire Department (BCFD) during which firefighters installed smoke alarms and accompanying safety educators provided information about injury risks and the benefits of working smoke alarms, carbon monoxide alarms, and safe hot water temperatures.

A sample of 708 homes participating in the intervention visit (“participants”) were visited between 6-9 months later for a follow up survey and observations of the home safety behaviors addressed during the BCFD visit. A sample of 278 neighboring households that were not available to participate in the intervention visit was also recruited and completed the survey and observations. These “non-participant” households were recruited from the same blocks as the participants. All households voluntarily participated in the study and all came from one of 12 census tracts in Baltimore City that had been selected to participate in the community trial. Data were collected between January 2011 and December 2011.

The study was approved by the Johns Hopkins Institutional Review Board. Data were collected through an interviewer-administered, computer-assisted survey conducted in the home. Following the survey, data collectors used a standard protocol to record the hot water temperature and to observe selected water heater characteristics, as described below. Of the 986 households surveyed, hot water temperature measurements were available for 975 (99%). Of these, we observed the water heater characteristics in 883 households (91%); the remainder were not accessible to the data collectors, or the resident did not grant permission.

## Measures

**Household Characteristics—**Respondents reported household size, income, owner status and composition. Using self-reported household income and the number of people supported on that income, the household was classified as living in poverty if the income was below the 2010 Federal Poverty Guidelines.[23]

**Observed Hot Water Temperature—**A standard kitchen candy thermometer was used to test the temperature of the hot tap water. Candy thermometers provide a measure of temperatures between 75$^{o}$ F and 400$^{o}$ F. Water temperature was tested in the kitchen. Data collectors were instructed to completely open the hot water faucet for one minute, fill a cup with that water, and then measure the temperature with the candy thermometer. Hot water was considered “safe” if the temperature was 120°F or less.

**Water Heater Characteristics—**Data collectors observed and recorded characteristics of the water heater including type (gas or electric), date of manufacture, capacity, and the descriptors used on the temperature gauge (i.e., 1, 2, 3… or vacation setting, warm, hot, hottest). Gallons of water per person living in the home was obtained by dividing the water heater capacity by the reported number of people living in the home. Data collectors made a sketch of the gauge indicating the temperature setting.

**Gauge—**To standardize the setting of the gauge, the total area of the gauge was translated into a 0-100% scale based on the available area for the setting. For example, if the gauge was set at 3 and the highest possible setting was 6, the setting was calculated as 3/6 or 50%. The 0-100% scale for gauges was then divided into quarters and analyzed as a categorical variable. Virtually all of the electric water heaters (96%) did not have a visible gauge and therefore only gas water heaters were included in our analysis of gauge.

## Data Analysis

Chi-squared testing was used to compare household characteristics and water heater features between homes with safe versus unsafe hot water temperatures. We also examined whether proportions of safe hot water temperatures differed between the two samples (participants and non-participants in the intervention) and between measures taken in the winter (November-February) versus summer (March-October) months.

A multivariate logistic regression analysis was performed on the presence of safe hot water temperature, including homeowner status, type of water heater, and gallons per person. Poverty status and age of the water heater were not associated with the presence of safe hot

water temperatures in bivariate analyses and therefore were not included in the model. Number of people in the home and water heater volume were excluded from the model because these variables were combined to create a gallons per person variable. Households with missing data were excluded from the model. All analyses were performed using Stata software (Stata version 11, StataCorp, College Station, TX).

## Results

Hot water was observed to be above the recommended 120° F in 401 homes (41%), including 260 homes (27%) with temperatures at or above 130°F. Homeowners were more likely to have safe hot water temperature than renters (63% vs. 54%; $p<0.01$) (Table 1). Homes with safe hot water temperature on average have fewer people than homes with unsafe hot water. No differences in hot water safety were detected between participants and non-participants or between winter and summer seasons.

A majority (74%) of water heaters observed were gas water heaters of 40 gallons or less. Electric water heaters were more likely than gas water heaters to have safe hot water temperatures (85% vs. 55%; $p<0.01$) (Table 2). Large water heaters with over 40 gallons were more likely than smaller ones to have safe hot water temperatures (67% vs. 57%; $p=0.02$). Increasing hot water capacity per person in the home was found to be protective; households with over thirty gallons of hot water per person were less likely to have unsafe hot water temperatures (73% vs. 27%; $p<0.01$). No difference in water temperatures was observed across water heaters of different ages; only 159 (29%) water heaters were more than 10 years old and 7 of these were manufactured before the voluntary standard was adopted 24 years ago.

Although the hot water temperature was generally correlated with the gauge setting on the gas water heaters, there were instances of concerning inconsistencies. Among gas water heaters, three of the ten gauges that were set at less than 25% of their maximum setting had unsafe hot water temperatures (Figure 1). Furthermore, for 76 (11%), the water temperature was dangerously hot (at or above 130°F) although the gauge was set at less than 75% of its maximum setting.

In the multivariate logistic regression including the homeowner status, type of water heater, and number of gallons per person, all three variables retained their significance (Table 3). Homeowners were more likely to have safe hot water temperatures than rental properties (OR=1.47; $p=0.02$). The odds of having a safe hot water temperature were 4.99 times higher for homes with an electric water heater compared to homes with a gas water heater ($p<0.01$) and 2.12 times higher for homes with over 30 gallons per person in the home compared to 10 or less gallons per person ($p=0.01$).

## Discussion

Our results demonstrate that hot water is at dangerously high temperatures in 4 out of 10 homes in a large urban sample, despite the fact that voluntary standards by water heater manufacturers to preset temperatures at the factory were adopted over twenty years ago.

Almost all (99%) of the water heaters in our sample were purchased since the voluntary standard was implemented.

Two protective factors emerged which warrant mention. The first is that electric water heaters were significantly more likely to be at a safe temperature compared to gas water heaters, even after adjusting for homeowner's status and gallons per person. Unlike gas water heaters, adjusting the temperature on an electric water heater requires a licensed professional. Though electric water heaters appear to be protective, recommendations of electric versus gas will need to include cost considerations, as electric heaters cost three times as much to operate as gas.[24] A further consideration is that gas is not available in all places. Moreover, families, especially those living in rental properties may not have a choice between a gas or an electric water heater.

The second protective factor that emerged was that larger water heaters were more likely to have safe temperatures. The amount of water per person was a significant factor associated with the water temperature, even after adjusting for whether the water heater was gas or electric. We hypothesize that residents may increase the temperature to provide sufficient hot water for household needs such as showers. Therefore, it may be prudent to advise consumers (including landlords) to consider manufacturer recommendation matching the number of people in the home to the volume of the water heater. Information is currently available on water heaters advising consumers of the product's energy efficiency rating; safety information could be added to those materials to help families understand the importance of choosing a water heater with the appropriate capacity to meet the needs to the family.

As water heater temperature continues to pose scald burn risks despite the voluntary standard, it is important to consider additional technological control measures. We were surprised by the variation in water heater thermostat dials, and that none were observed to have an indicator of a safe temperature or a safe temperature range. Furthermore, our data support the previously recognized discrepancies between water heater gauges and the temperature of the water produced. Although gauge setting in our sample is generally correlated with temperature, it is not always the case. In 11% of gas water heaters we found that the water temperature was dangerously hot (at or above 130°F), although the gauge was set at less than 75% of its maximum setting. Although it may not be technologically feasible to have a gauge that represents the exact temperature at the tap, efforts to better design the water heater thermostat are needed to enable professionals and residents to easily set it to 120°F and help them understand the potential variation between the set temperature and the maximum temperature.

Given the limitations of reducing tap water temperature through current thermostat technology alone, other existing strategies should be prioritized. One potential solution is to equip faucets with anti-scald devices, such as a thermostatic mixer valve as recommended by the 2009 International Residential Code for One- and Two-family Dwellings.[25] Thermostatic mixer equipped valves limit water temperature to a maximum of 120°F.[25] Thermostatic mixer valves allow hot tap water to be set at a fixed temperature outside of the water heater and without affecting the temperature of stored hot water in the tank.[26] Other

anti-scald devices such as anti-scald aerators and scald guards interrupt the flow of water at a set temperature, usually before the temperature reaches 120°F, allowing the water to reach a safe level before the faucet reactivates.[4] Edwards et al. quantified the effects of a thermostatic control system on the prevalence of dangerous water temperatures in a cluster randomized controlled trial in London.[27] Results showed that the prevalence of dangerous hot water temperatures was significantly reduced and gas consumption was not significantly affected.[27] The cost of installing thermostatic mixing valves has been estimated at $250 per room ($100 for the valve and $150 for installation).[28] A cost analysis of mass installation in government managed housing in England estimated installation costs at £13.68 (~$22), which included parts, maintenance, and educational material but not labor.[29] Kendrick et al. believe that mass installation could result in significant savings to the British national health care system.[26] Financial incentives to include such technology in renovation and remodeling plans should be assessed.

Whether and how the voluntary standard is being implemented is another consideration that may explain the high settings recorded on some of the water heaters in our sample. We are unaware of any effort to observe manufacturer participation in the voluntary agreement. Nor do we know who installed the water heaters in the homes we observed, and if the installer or the resident had adjusted the temperature above the manufacturers' preset level.

Until engineering solutions can be implemented on a large scale, attention must be paid to educational messages. Educational messages aimed at informing families of the dangers of high water temperatures are needed. In addition, routinely encouraging heads of household to set their water heaters to 120°F can provide a no cost strategy to address this risk.[30,31] Importantly, our study demonstrates the challenges of implementing such recommendations. A majority of water heaters we examined did not have easy-to-understand gauge settings to allow consumers to set their hot water heater to 120°F. It is vitally important that educational messages be revised to include instructions to test hot water temperatures after adjusting gauges to insure that a safe temperature is achieved through the gauge adjustment. This message is consistent with current American Burn Association recommendations.[4] In addition to providing a gauge as to the temperature, the water heater could indicate that the recommended temperature is 120°F and provide educational information about how fast a scald burn can occur at higher temperatures.

A complementary approach to the above engineering and educational strategies is to consider policy options for improving the safety of water heaters, a consumer product. Past efforts to intervene at the state level prompted voluntary action by water heater manufacturers. Factory presets of safe hot water temperatures offered a first step toward increasing the safety of hot water heaters. We now know that additional efforts are needed. In our opinion, designing water heaters with gauges that are easy to read and labeling that explains the risk and how to test and adjust the temperature is a needed next step and represents a basic component of safety for this consumer product. As such, this is an area the U.S. Consumer Product Safety Commission is well-positioned to assess and determine whether their experience and authority could be useful in improving the current situation.

There are limitations to our study. Our findings are based on a single water temperature reading, and do not take into consideration possible fluctuations in the hot water temperature that may occur, for example, throughout the course of the day. Furthermore, water heater gauges in our sample varied considerably; we standardized the dial to a more intuitive percentage, but this does not reflect the true complexity of the gauge setting. Finally, our sample, although large and diverse, was self-selected and generalizations to other urban areas should take this into consideration. Despite these limitations, our results provide the first systematic assessment of water heater temperatures in a large sample of urban homes, and clearly demonstrate the need for more comprehensive scald prevention interventions and engineering solutions.

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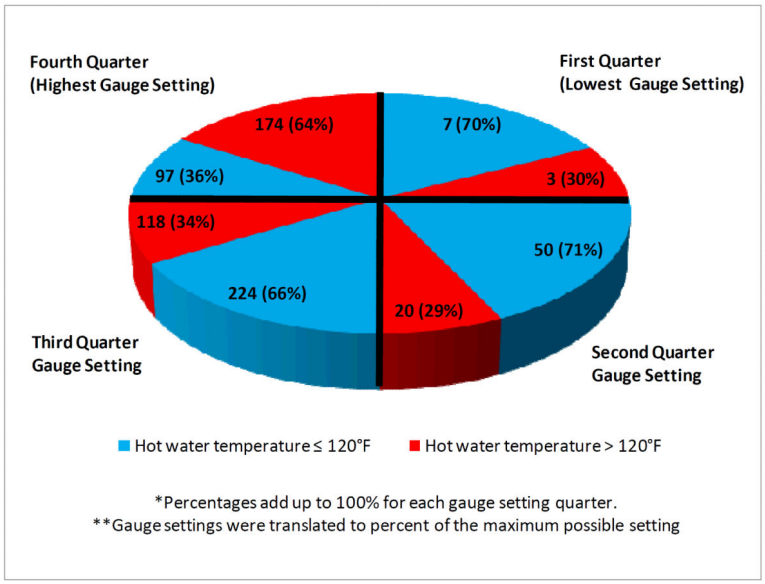


**Figure 1.**
Water Heater Gauge Setting and Hot Water Temperature among gas water heaters, N=693

## Table 1

Household characteristics

| | Hot Water 120 or Less N=574 | Hot Water Over 120 N=401 | Total N=975 | Test Statistic |
|---|---|---|---|---|
| | N (%) | N (%) | N (%) | |
| Household Income[1] | | | | |
| At or below the 2010 Federal Poverty Level | 123 (57) | 94 (43) | 217 (100) | $\chi^2$=1.7 (p=0.19) |
| Above the 2010 Federal Poverty Level | 363 (62) | 225 (38) | 588 (100) | |
| Homeowner Status[1] | | | | |
| Rent | 238 (54) | 202 (46) | 440 (100) | $\chi^2$=7.6 (p<0.01) |
| Own or pay mortgage | 330 (63) | 195 (37) | 525 (100) | |
| Number of People Who Live in the Home | 2.99 (0.07) | 3.39 (0.09) | 3.16 (0.06) | t=3.4 (p<0.01) |

[1]Of the 976 households with hot water temperature measurements, 170 did not provide information on the household poverty status, and 10 did not provide information on the homeowner status.

## Table 2

Water heater safety

| Hot Water Characteristics | Hot Water 120 or less N=524 | Hot Water over 120 N=359 | Total N=883 | Test Statistic |
|---|---|---|---|---|
| | N (%) | N (%) | N (%) | |
| Type of Water Heater[2] | | | | |
| Gas | 402 (55) | 333 (45) | 735 (100) | $\chi^2$=40.7 (p<0.01) |
| Electric | 107 (85) | 19 (15) | 126 (100) | |
| Volume of Water Heater[2] | | | | |
| Small (40 gallons or less) | 361 (57) | 277 (43) | 638 (100) | $\chi^2$=5.4 (p=0.02) |
| Large (More than 40 gallons) | 108 (67) | 54 (33) | 162 (100) | |
| Age of Water Heater[2] | | | | |
| 0-2 years | 53 (53) | 47 (47) | 100 (100) | $\chi^2$=2.5 (p=0.47) |
| 3-5 years | 56 (60) | 37 (40) | 93 (100) | |
| 5-10 years | 106 (55) | 88 (45) | 194 (100) | |
| More than 10 years | 97 (61) | 62 (39) | 159 (100) | |
| Gallons per Person[2] | | | | |
| 10 gallons | 144 (51) | 139 (49) | 283 (100) | $\chi^2$=20.5 (p<0.01) |
| 11 to 20 gallons | 191 (58) | 138 (42) | 329 (100) | |
| 21 to 30 gallons | 69 (71) | 28 (29) | 97 (100) | |
| Over 30 gallons | 64 (73) | 24 (27) | 88 (100) | |
| Gauge Setting[3] (Gas Heaters Only) | | | | |
| 0-25% | 7 (70) | 3 (30) | 10 (100) | $\chi^2$=63.9 (p<0.01) |
| 26-50% | 50 (71) | 20 (29) | 70 (100) | |
| 51-75% | 224 (66) | 118 (34) | 342 (100) | |
| 76-100% | 97 (36) | 174 (64) | 271 (100) | |

[2]Of the 884 households with hot water temperature measurements, N=22 the type of water heater could not be determined, N=337 the age of the water heater could not be determined, and N=83 the volume could not be determined, and N=86 gallons per person could not be determined.

[3]Of the 736 gas water heaters included in the gauge analysis, N=42 the gauge setting could not be determined.

**Table 3**

Multiple logistic regression analysis of safe hot water temperature (N=787)

| | Odds Ratio | Standard Error | P-value |
|---|---|---|---|
| Homeowner Status | | | |
| Rent | 1 | | |
| Own | 1.47 | 0.23 | .02 |
| Type | | | |
| Gas | 1 | | |
| Electric | 4.99 | 1.40 | <0.01 |
| Gallons per person | | | |
| 10 gallons | 1 | | |
| 11 to 20 gallons | 1.22 | 0.21 | 0.25 |
| 21 to 30 gallons | 1.69 | 0.46 | 0.05 |
| Over 30 gallons | 2.12 | 0.60 | 0.01 |